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ABSTRACT
There is a need to establish research continuity to enable educators to discern trends in student learning and relate changes in student responses to different teaching methods. Generally, small classes seem more effective than large, discussions are preferred over lectures, and student-centered discussions over instructor-centered for better retention, application, problem solving, attitude changing, and motivation for further learning. The author concludes that teachers should be encouraged to develop a repertoire of skills to allow students enough options to maximize their motivation and learning. This Review covers research in college teaching from 1924 to 1970, and contains an extensive bibliography. (WM)

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RESEARCH ON COLLEGE TEACHING:

A REVIEW

Wilbert J. McKeachie

Report 6

ERIC Clearinghouse on Higher Education
The George Washington University
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FOREWORD

This comprehensive review covers research on college teaching from 1924 to 1970, and discusses the relative effectiveness of such factors as class size, the lecture, discussion, independent study, and the use of new technological media. Its author, Wilbert J. McKeachie, Chairman of the Department of Psychology, University of Michigan, is well known for his own research and writing on college and university teaching.

The sixth in a series of reports on various aspects of higher education, this paper represents one of several kinds of Clearinghouse publications. Others include short reviews, bibliographies, and compendia based on recent and significant documents found both in and outside the ERIC collection. In addition, Clearinghouse staff abstract and index the current research literature of higher education for publication in the U.S. Office of Education's monthly volume, *Research in Education*. Readers who wish to order ERIC documents cited in the bibliography should write to the ERIC Document Reproduction Service, National Cash Register Company, 4936 Fairmont Avenue, Bethesda, Maryland 20014. When ordering, please specify the ERIC document (ED) number. Payment for microfiche (MF) or hard/photo copies (HC) must accompany orders of less than $5.00.

Dr. McKeachie would like to express appreciation for the comments of his colleagues, Stanford Ericksen, Frank Koen, and John Milholland, on an earlier draft of his paper, and also for the assistance of Anne Taylor in gathering references.

Carl J. Lange, Director
ERIC Clearinghouse on Higher Education
November 1970

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The first empirical study on college teaching was, so far as I can determine, published by Edmundson and Mulder in 1924. Since that first publication, there has been a steady flow of reports. Unfortunately, the progress to be noted is not great. The Edmundson and Mulder study would not look greatly out of place in a current journal.

Research on college teaching has been marked by non-significant differences. Whether the researcher attempted to demonstrate that his favorite method was the answer to all our teaching problems or a skeptic intended to disprove the claims of enthusiasts, the results have been the same—"no significant difference."

Does that mean that it doesn't matter how one teaches? Not so. When one reviews all of the studies, consistencies do emerge. We now have some reasonably well supported answers to such basic questions about college teaching as:

"Does size of class affect teaching effectiveness?"

"Is lecture as effective as discussion?"

"Do the new media improve teaching effectiveness?"

This paper reviews that research.

Class Size

The search for a research base for teaching began with the question of class size. Are small classes really more effective for teaching than large classes? The answer of the professor has generally been "Yes." But the refreshing empiricism of the 1920s looked hard at many "self-evident truths" about human behavior. Among them was the assumption that class size had something to do with educational effectiveness.

Edmundson and Mulder (1924) compared the performance of students enrolled in a 109-student class matched for intelligence with students enrolled in a 43-student class of the same course in education. Achievement of the two groups was approximately equal, with a slight edge for the small class on an essay and the mid-semester tests, and for the large class on quizzes and the final examination. Students reported a preference for small classes. The Edmundson and Mulder results at Michigan encouraged the Committee of Research of the University of Minnesota to begin a classic series of studies of class size. In 59 experiments involving such widely varying subject matter as psychology, physics, accounting, law, and education, 46 of the results favored the large classes. Although only eight differences were large enough to be statistically significant at the 5% level, six of the eight favored large classes (Hudelson, 1928).

Support for small classes, however, came from studies in the teaching of French conducted by Cheydleur (1945) at the University of Wisconsin between 1919 and 1943. With hundreds of classes ranging in size from 9 to 33, Cheydleur found a consistent superiority on objective departmental examinations for the smaller classes. Mueller (1924) found similar results in an experiment comparing elementary psychology classes of 20 and 40 students.

More recent experiments also favor small classes. Nachman and Opochinsky (1958) found a small class to be superior to a large class on surprise quizzes, but no significant difference between performances of the two classes on the final examination for which both groups prepared. In the Macomber and Siegel experiments at Miami University (1957a, 1957b, 1960), significant differences favoring small classes were found on measures of change in misconceptions in psychology, on a case test of problems in a course in marketing, and on measures of student attitudes toward all the courses. When retention of knowledge was measured one to two years after completion of the courses, small differences favored the small class (Siegel, Adams, and Macomber, 1960) in eight of the nine courses compared. Differences were also revealed in the more subtle and persisting outcomes in Feldhusen's (1963) study showing that a small class in educational psychology produced more change in attitudes toward teaching than a large class.

Few of us are satisfied with achievement of knowledge if it is not remembered, if the student is unable to use it in solving problems, or if the student fails to relate the knowledge to relevant attitudes. If one considers the basic outcomes of retention, problem solving, and attitude differentiation, *the weight of the evidence clearly favors small classes*. Moreover, in almost all studies, students and faculty members tend to prefer small classes. Other things being equal, one would prefer to cultivate or maintain high student and faculty morale.

It is economically impractical, however, to teach entirely in small classes. If we are to make wise decisions about when and where small classes are most important, we need to analyze more carefully the changes in educationally relevant variables associated with changes in size. Thomas and Fink (1963), suggest that two types of input increase with increasing group size—resource input (skills, knowledge, etc.) and demand input (needs). It is clear that the more group members, the greater the likelihood that some members will have resources of knowledge, intelligence or other skills needed for the educational purposes of the group. It seems likely, however, that there is a limited amount of relevant knowledge and skills, so that beyond some point additional students contribute little that is not already in the group's resources.

A group's utilization of resources is constrained by the simple facts that: (1) in a large group, a smaller proportion of group members can participate orally; and (2) the larger the group, the less likely that a given person will feel free to volunteer his contribution. As the size of the class increases, the number of different demands or needs of members also increase. It is unlikely that the ability of the instructor and class to meet different students' expectations increases proportionately, since class time is not expandable.

In most courses there are several levels of goals–knowledge, critical thinking, attitudes toward learning, etc. The teacher's task is to find methods that will achieve an optimal balance of all of these. If different methods are effective for different objectives, the teacher needs to be able to use an optimal combination of these methods. Unfortunately, most teaching research has studied the effect of one method versus another–painfully repeated day after day for a semester–thus we have little evidence on the realtive effectiveness of differing combinations or degrees of flexibility in teaching methods.

Whereas teachers could exercise much more imagination and variety of teaching methods in large groups than they usually do, it is probably true that in large groups more time is devoted to lecturing than in smaller classes. The large class often reduces the teacher's sense of freedom in choosing teaching methods, assigning papers, or testing to achieve varying objectives. Of course, teachers in small classes may lecture just as rigidly as in large classes, and a small class does not guarantee that the teacher will make optimal use of his opportunities. Assuming, however, that teachers have some repertoire of appropriate skills, anything that handcuffs instructors is likely to be educationally damaging, and this may be the major way in which large classes tend to sabotage education.

To conclude, it is commonplace to suggest that the effect of class size depends upon the method used, and it is probably true that the size of the group is less critical for the success of a lecture, for example, than for that of a discussion. Moreover, class size interacts with student characteristics: i.e. small classes are educationally more important for some students than for others. But most important, our analysis of research suggests that the importance of size depends upon educational goals. In general, large classes are simply not as effective as small classes for retention, critical thinking and attitude change.

Lecture versus Discussion

Just as we need to look beyond the labels "large class" or "small class" to the teaching methods being used, so too we need to look beyond the labels "lecture," "discussion," "laboratory," etc. to the procedures actually being used. Each of these labels includes a wide variety of teaching procedures–good and bad. While the labels give us a general notion of the procedures likely to differentiate one method from another, we need to keep in mind that not every lecture or every discussion fits our stereotypes and that often what really determines what the student learns is not the apparent method but such other factors as the sort of tests the teacher constructs and how the student expects to be evaluated for a grade.

Research on the lecture method is almost as hoary with age as that on class size. Table 2 summarizes the studies to date. As Table 2 indicates, almost a half-century of research results indicate that the preferred method depends on one's goals in teaching. Effects shown on tests of factual knowledge are not consistent, but in studies that have measured problem-solving ability, attitudes, or motivation, the results have favored the discussion method.

Many universities and large colleges use a method of distributing class meetings between lectures and discussions. This administrative arrangement is supported by research. In an experiment in which discussion meetings were substituted for one-third of the lectures (Lifson, Rempel and Johnson, 1956) in psychology, there were no significant differences in achievement between groups. Compared with all lectures, however, the partial discussion method resulted in more favorable student attitudes which persisted in a follow-up study two years later. Eash and Bennet (1964) found that achievement was higher in psychology classes taught in three lectures (200 students) plus one 15-student discussion period per week, than in classes taught four times a week in lecture/discussion classes of 30-50 students. Similarly, Lancaster, Manning, White and others (1961), and Warren (1954) found that the more course time was devoted to recitations in proportion to lectures, the better students achieved in physics. Giffin and Bowers (1962) found that introduction of one mass lecture per week into a course in speech did not result in loss of achievement, and Gnagey, Cheseboro and Johnson (1968) obtained similar results in an educational psychology course.

The conclusion to be drawn from these studies seems to be that a combination of large lecture and small discussion sections is preferable to the common arrangement of several sections of unwieldy medium size.

Student- vs. Instructor-Centered Teaching

In the period following World War II, interest burgeoned in those kinds of discussion methods giving great emphasis to student responsibility. While this interest waned during the 1950s, it revived in the late 1960s and a great many teachers tried methods in which the teacher's traditional role as an authority was altered. T-Group or encounter group techniques were incorporated into many courses. As Table 3 indicates, the results favor student-centered teaching for the more complex educational outcomes.

These results are so consistent that they suggest a greater effort should be made to train teachers in the

Table 1

Class Size

Reference	Course	Criteria		
		Factual Exam	Higher Level Retention & Thinking	Attitude, Motivation
Nachman & Opochinsky (1958)	Psychology	S*		
Mueller (1924)	Psychology	S		
Elliott (In Beardslee and Birney, 1951)	Psychology			S
Feldhusen (1963)	Educational Psychology			S
Casey & Weaver (1956)	Human Development			S*
Macomber & Siegel (1957, 1960)	Psychology, Marketing		S*	S*
Siegel, Adams, Macomber (1960)	Psychology, Marketing		S(8 out of 9)	
McConnell (1968)	Economics	L = S	S	L
Hudelson (1928)	Psychology	L(46 exp.)		
	Physics	S(13 exp.)		
	Accounting			
	Law	*L(6 exp.)		
	Education	*S(2 exp.)		
Edmundson & Mulder (1924)	Education	L	S	
Cheydleur (1945)	French	S(1240 classes)		

L = Large class superior
S = Small class superior
* = Difference significant at .05 level or better. All other results are the actual direction of the difference in the experiment.

skills of student-centered discussion teaching. A student-centered discussion is not simply one in which the instructor abdicates and sits in the back of the classroom. Failures with student-centered teaching often come when teachers find that skills of listening, democratic decision making, conflict resolution, etc., are not in their repertoire. Moreover, students need to learn new skills in order to make optimal use of a student-centered classroom. The teacher needs to know how to help students learn these skills as well as the course content. These skills can be learned, and some success in using them will, in turn, reinforce the underlying attitudes toward students and learning basic to student-centered teaching.

Probably the most "1984ish" uses of discussions are found in colleges where a number of meeting rooms are linked to a central monitoring room as that the instructor can listen in and interpose comments in any of several

Table 2

Lecture versus Discussion

Reference	Course	Criteria		
		Factual Exam	Higher Level Retention & Thinking	Attitude, Motivation
Spence (1928)	Education Psychology	L*		
Remmers (1933)	Elementary Psychology	L		
Husband (1951)	General Psychology	L		
Lifson, *et al.* (1956)		L = D		D*
Leton (1961)	Child Dev.	L		D
Ruja (1954)	General Psychology Philosophy	L* (4 classes) D (2 classes)		
Elliott (In Beardslee & Birney, 1951)	Elementary Psychology			D
Casey & Weaver (1956)	Human Dev. & Behavior			D
Hill (1960)	Anthropology (15 classes)	D		D
Bane (1925)	Education (5 experiments)	L(3) D(2)	D*(5)	
Veenker & Ismail (1962)	Health			L = D
Solomon, *et al.* (1964)	Government	L	D	
Gerberich & Warner (1936)	Government	L		L
Barnard (1942)	Science (6 classes)	L	D	D*
Dawson (1956)	Elementary Soil Science (6 classes)	L	D	
Lancaster & Erskine (1962)	Mathematics	L		
Lancaster, *et al.* (1961)	Physics	D		
Warren (1954)	Physics	D		
Ward (1956)	Physical Sci.	L = D	D*	
Montean (1959)	Chemistry & General Sci.	D	D*	

L = Lecture superior
D = Discussion superior
* = Difference significant at .05 level or better. All other results indicate the actual direction of difference in the experiment.

Table 3

Student-Centered Discussion versus Instructor-Centered Discussion

Reference	Course	Criteria		
		Factual Knowledge	Higher Level Cognitive	Attitude Motivation
Faw (1949)	Psychology	S*		S
Asch (1951)	Psychology	I*		S
Haigh & Schmidt (1956)	Child & Adolescent Psychology			S
Guetzkow, Kelly & McKeachie (1954)	General Psychology	I		S
Landsman (1950)	Human Development			
Johnson & Smith (1953)	Intro. Psychology			S (2 classes)
Bills (1952)	General Psychology			S*
Maloney (1956)	Educ. Psychology			S
Slomowitz (1955)	Grad. Counseling			S
Deignan (1955)	Psychology			S
Rasmussen (1956)	Educ. Psychology			S
Krumboltz & Farquhar (1957)	"How to Study Course"			
Burke (1955)	College Freshman Orientation	I		
Lyle (1958)	General Psychology		I (critical thinking)	
Jenkins (1952)	English			
Wispe (1951)	Social Relations			
Ashmus & Haigh (1952); Haigh & Schmidt (1956)	Child & Adolescent Psychology			S
Moore & Popham (1956)	Educ. Psychology			S
Zeleny (1940)	Sociology			S
Bovard (1951a, 1951b)	Psychology		S	S
McKeachie (1951)	Psychology		S	S & I
Patton (1955)	Psychology		S	S*
Carpenter (1959) & Davage (1957a, 1957b)	Psychology	S*	S*	S*
Gibb & Gibb (1952)	General Psychology			S*
DiVesta (1954)	Human Relations			S
Anderson & Kell (1954)	Psychology			S
McKeachie (1954)	Psychology			S
Wieder (1959)	Psychology			S

I = Instructor-Centered superior
S = Student-Centered superior
* = Difference significant at .05 level or better. All other results are the actual direction of the difference in the experiment.

student-led discussions. Leuba (1963) reports satisfying results of using this technique in psychology courses. Earlier research at Antioch (Baskin et al., 1961; 1962), however, found no consistent differences in effectiveness between small, student-led groups and conventional instructor-led lecture/discussion.

In experiments in educational psychology and general psychology, Gruber and Weitman (1962) found that students taught in small discussion groups without a teacher not only did at least as well on a final examination as students who heard the teacher lecture, but they were also superior in curiosity (as measured by

question-asking behavior) and in interest in educational psychology. The discussion students reported a larger number of readings during the term, while the lecture students reported more attempts to apply their learning. In one experiment in Physical Optics, the lecture students were superior to student-led-discussion students on a test of facts and simple problems but inferior on a test containing complex problems and learning new material. The superiority of student-led discussions was particularly marked for students below the median in ability. In Beach's studies (1960; 1968), students high in sociability achieved significantly more on a factual test than did less sociable students in small student-led discussions, but less sociable students achieved more than sociable students in lecture/discussion sections. In his second study (1968), the student-led discussion groups were superior to the instructor-led group in such criteria as quality of study and amount of required and non-required reading undertaken.

Webb and Grib (1967) report six studies in which student-led discussions were compared with instructor-led lectures or discussions. In some of the experiments, both experimental and control groups also heard lectures each week. In two of the six studies, significant differences in achievement tests favored the student-led discussions. In the other four, differences were not significant. Both students and instructors reported that the student-led discussions increased student motivation; and students who had been exposed to student-led discussions tended to favor them over instructor-led discussions as supplements to lectures.

Student-led discussions thus appear to be a useful method of providing the values of small-group discussion, not only when staff resources are too limited to permit teacher-led groups, but even when regular teaching staff are available. We have already seen that permissiveness is a teacher characteristic that contributes to effectiveness. Webb and Grib (1966) note students report that the sense of freedom to ask questions and express their own opinions is a major advantage of the student-led discussions. It makes theoretical sense that this opportunity to expose one's own ignorance and vent one's feelings should contribute to learning.

Probably the most convincing demonstration of the effectiveness of student-led discussions is the "Pyramid Project" carried out at Pennsylvania State University (Carpenter, 1957; Davage, 1959a; 1959b). In this project, a faculty member, graduate students, and seniors planned the activities for the program. The seniors assisted by juniors led small group discussions. In courses in sociology and psychology, these small discussion sections led by more advanced undergraduate students supplemented the regular course activities. Compared with supplementary instructor-led lectures, film presentations and demonstrations, or no supplement, the small groups led by juniors and seniors read more, were more likely to go on to major in the subject, had more favorable attitudes toward the role of sociologists (or psychologists), accepted more responsibility for their own learning (in psychology), showed a more intellectual (less vocational) attitude toward college, and performed better on tests of scientific thinking, persistence in critical thinking and resourcefulness in problem solving. Equally important was the favorable effect of the experience upon the junior and senior group leaders.

Trowbridge (1969) similarly found favorable results with small groups led by advanced undergraduates supplementing lecture, reading and projects. The experimental group was superior to students in a conventional lecture/discussion class both on a standardized test of achievement and on change in self-concept.

The consistency of results favoring student-led discussions should not lead one to the conclusion that the solution to our teaching problems is simply to organize all our classes into student-led groups. Many of those involved in these studies report that students often lack the ability to share the responsibilities of discussion leadership and membership in a learning group. Faculty members successfully using student-led discussions typically spend a good deal of time in planning, providing structure, and training leaders and group members.

Print Material and Programmed Learning

A quiet revolution in teaching has occurred over the past few years. This is the revolution in the use of printed materials, such as paperback books, offprints of journal articles, facsimile or microfilm copies, and other duplicated materials. As a result of this change in techniques of presenting, reproducing, marketing, and circulating printed materials, not only is the student now able to own a richer variety of resources, but the new open-stack libraries invite him to go beyond his assignments to books and journals giving other viewpoints and additional information.

What is most lacking is research on effective methods of using printed materials. McKeachie and Hiler (1954) demonstrated that students learn facts about which questions are asked, and Cashen and Leicht (1970) found underlining to be useful. The classic study of Gates (1917) also illustrates the value of active questioning and recitation versus passive reading.

Kaplan (1964) describes the use of reading logs in which students are expected to spend a major part of their study time reading books and articles of their own choice. He reports (and my own experience confirms) that students not only read a great deal but that their logs show marked improvement in critical and integrative ability. The key to this improvement probably lies in extensive teacher comments upon the logs, which are periodically turned in to the instructor. Kaplan reports favorable student reactions, but little research has been reported comparing different techniques of utilizing printed materials.

Table 4

Student-Led Discussions

Reference	Course	Criteria		
		Factual Knowledge	Higher Level Cognitive	Attitude Motivation
Gruber & Weitman (1962)	Physical Science	SLD		
	Educ. Psychology	SLD	SLD	SLD
	General Psychology		SLD	SLD
	Optics	L	SLD	
Beach (1968)	Social Psychology	L		SLD
Beach (1960)				
Webb (1965)	Psychology	SLD		
Webb & Grib	Statistics	SLD*		
	Philosophy	SLD		
	Philosophy	TLD?		
	English	SLD*		
	English	TLD		
	Art	SLD		
Davage (1959a)	Sociology (2 experiments)			SLD*
Carpenter (1959)	Psychology (3 experiments)		SLD*	SLD*
Davage (1959b)	Meteorology (2 experiments)	mixed	mixed	mixed
Trowbridge (1969)	Educ. Psychology	SLD	SLD	SLD
Gnagey (1962)	Educ. Psychology	TLD		

SLD = Student-Led discussion
TLD = Teacher-Led discussion
L = Lecture

In addition to the early work of Pressey (1926; 1950), Angell (1949), Peterson and Peterson (1931), and Stephens (1953) found that immediate knowledge of results on a quiz or special answer sheet produced results superior to those obtained by the delayed knowledge of results obtained from use of answer sheets returned to students at the next class meeting.

One of the newer developments in textbook construction is the "programmed textbook," an instructional book developed by utilizing the learning-in-small-steps sequence of the conventional teaching machine. Such books and booklets are sometimes designed as adjuncts to normal teaching materials and sometimes intended to replace textbooks.

The research of Newman (1957) challenges the basic assumption that psychologists or educators are more able than students to structure an optimal learning situation. Newman found that students who used their own techniques to learn names of electrical symbols did better than those following a learning plan based on learning principles. Research on the use of programmed materials has produced some examples in which programming was superior to conventional instruction and others in which it was inferior. Whitlock, Copeland, and Craig (1963), for example, report that programmed materials in statistics proved to be more effective than conventional lecture, discussion, and textbook instruction; differences in the same direction persisted in a second experiment in which

the programmed course was compared with independent study of a textbook. Bartz and Darby (1966) however, found that students using a programmed text in mathematics achieved less than those using a conventional textbook. Other research has produced similarly contradictory results (Bergman, 1963; Carlsen, 1966; Elder et al., 1964; Fels and Starleaf, 1963; Lane, 1964; Oakes, 1960; Roe, 1962). In a correspondence course, a clearcut superiority, however, was found by Wilson (1968) for week-by-week assignments with prompt feedback compared with a method in which students received the whole course in one package. The week-by-week group were much more likely to complete the course.

Three experiments in computer-assisted college-level instruction have been reported and two (Grub and Selfridge, 1963) showed savings in time and improved performance for computer-assisted instruction compared with conventional instruction and programmed text. Moreover students liked the computer. With computer programs of this sort, the motivational value of unexpectedness can be retained, and programs can be adopted for students of differing types. Cooper (1969), on the other hand, found no advantage for computer-based instruction in statistics. So far, the development of courses for computer-aided instruction lags far behind the development of hardware. Some computer teaching programs make little use of the computers' flexibility. Consequently, the computer has had little impact in changing instructional methods in college.

Programmed learning, however, has blossomed into courses involving the use of lectures, programmed materials, student-led discussions, individual tutoring, multiple quizzes, books, laboratory experiments, and psychedelic multiple-screen audio-visual presentations all sequenced in carefully planned combinations. One of the models for these contingency courses is the course developed by Keller for the University of Brasilia and used at Arizona State and Western Michigan (Keller, 1968). Courses modelled after Keller's share with programmed learning the emphasis on careful step-by-step planning, but involve a variety of methods and media. Keller's course, for example, divided course work into 30 units. Before moving from one unit to the next, the student was required to show his mastery of the unit by passing a test or carrying out an experiment. Lecture/demonstrations were not compulsory and, in fact, students were not allowed to attend who had not passed the units necessary to indicate appropriate readiness. The course grade was determined not only by a final examination but also by the number of units completed.

Unfortunately, there seem to be few data indicating how such courses compare in effectiveness to conventional courses. Nelson (1970) describes an experiment in which a conventional lecture section with only mid-term and final examinations was compared with two experimental classes--an oral interview method and a short exam method. In the oral interview class, students were required to demonstrate their mastery of each unit in a 30-minute personal interview with the instructor or assistant. Written examinations were given after each five interviews. In the short exam class, a test was given on each unit and like the oral interview section, students were not allowed to go to the next unit until passing the previous one. Differences between methods were not statistically significant on tests of thinking and attitude although students in the experimental groups felt that the course had helped them acquire better study habits. Interpretation of Sheppard and MacDermot's (1969) study of a similar use of the oral interview method is complicated by a high percentage of "Drops" in the interview section and the fact that the criterion tests of achievement counted for grades for the control students but not for the interview students. In any case, the remaining interview students did perform better than control students on both objective and essay tests. Moreover, those students who remained in the experiment were more highly satisfied with the course than students in the control group taught by lecture and discussion. These results taken with Rothkopf's finding (1966) that the use of questions either before or after reading facilitates learning indicate the value of questions, whether oral or written. McKeachie and Hiler (1954) and Goldberg (1969), however, found that study questions or quizzes produced improved performance only on the same items given later or on very closely related ones. This points to a methodological problem in evaluating much research in programmed instruction. Sometimes the program and criterion tests have contained the same items. Thus we are simply comparing the performance of one group of students answering questions a second time with that of students facing the questions for the first time. Ideally, the criterion measure of achievement should be constructed by someone not involved with either of the methods being compared.

Independent Study

One of the advantages of programmed materials is that they can be used with relatively little teacher supervision. They force the student to read carefully and actively. Thus the programmed learning movement has looked for allies among the proponents of independent study. If one goal of education is to help the student develop the ability to continue learning after his formal education is complete, it seems reasonable that he should have supervised experience in learning independently--experience in which the instructor helps the student learn how to formulate problems, find answers, and evaluate his progress himself. Unfortunately, most programmed instruction does little to help the student internalize standards by which he can evaluate his own work. Thus the emphasis upon prompt, regular feedback in programmed instruction may increase dependence rather than independence.

Independent study has a strong kinship with the project method which became popular more than a generation ago. One of the first "independent study" experiments was that of Seashore (1928). His course consisted primarily of guided individual study with written reports on eight projects, each of which took about a month to complete. Final examination scores, however, were no different for these students than for students taught by the usual lecture/discussion method (Scheidemann, 1929). In a study in a college botany course, Novak (1958) found that students in conventional classes learned more facts than did those taught by the project method. Similarly, Goldstein (1956) reports that students taught pharmacology by a project method did not learn more than those taught in a standard laboratory.

Measures of achievement such as those used in the studies just noted, unfortunately, are probably not sufficient measures of the purported objectives of project instruction. Presumably, the real superiority of the project method should be revealed in measures of motivation and resourcefulness. One morsel of support comes from Thistlethwaite's (1959) finding that National Merit Scholars checked requirement of a term paper or laboratory project as one characteristic of their most stimulating course; but most research on independent study has failed to find expected gains in motivation, learning, or even independence (McKeachie, 1963; Ulrich and Pray, 1965; Caro, 1962).

If one sends students home with the textbook only, they do better on a test of knowledge of the text than do students who have had a chance to get other ideas from a teacher or class discussion (Parsons, Ketcham and Beach, 1958; Parsons, 1957; Hartnett and Stewart, 1966). On the other hand, if students undertaking independent study are expected to read other books as well as the text, they probably will do less well on the examination on the text. Even this conclusion must be conditioned by the context. The Parsons, Ketcham, and Beach study, which produced the clearest supporting evidence, included a group of teachers who were enrolled for a Saturday class at a university. This group did not achieve as well with independent study as did control groups in classroom lectures or discussions.

One of the most comprehensive studies of independent study—that at Antioch (Baskin, 1962)—found no consistent differences among the use of lecture/discussion, student-led groups, and individual independent study. Bartz and Darby (1966) found in a course in mathematics that students undertaking independent study achieved *less* than did students in traditionally taught classes in spite of whether a regular or programmed text was used. Goldberg (1969) also found higher achievement in lecture than in self-study classes.

The most favorable results on independent study were obtained in the Colorado experiments discussed earlier (Gruber and Weitman, 1962). In addition to the studies reported earlier concerning student-led discussion, several experiments involved individual study or voluntary discussion. For example, in a course in Freshman English in which the group met only about 90% of the regularly scheduled hours and had little formal training on grammar, the self-directed study students' scores on a test of grammar were significantly superior to control groups. Gore's (1962) results using three to four students in teams were also positive.

The experiment reported by McKeachie, Lin, Forrin, and Teevan (1960) also involved at least a bi-weekly meeting with the instructor. The results of the experiment suggested that the "tutorial" students did not learn as much from the textbook as did students taught in conventional lecture/discussion section classes, but did develop stronger motivation both for course work and continued learning after the course.

Like the other methods reviewed, it is probable that independent study is particularly effective with certain types of students. Unfortunately, we have only glimmerings of knowledge about which student characteristics are significant here. McCullough and Van Atta (1958) found that students who are less rigid and less in need of social support are likely to profit more from independent study than are students scoring high in these characteristics. Koenig and McKeachie (1959) found that women high in need for achievement preferred independent study to lectures; and Patton (1955) similarly found that students high in need for achievement assumed responsibility and learned well in a class with low instructor direction.

These and other studies lead to the conclusion that if a student knows that he is going to be tested on the factual content of a particular book, it is usually more advantageous for him to read that book than to participate in other educational activities. But knowledge of specific facts is not the typical major objective of an independent study program. It generally aims for greater integration, increased purposefulness, and more intense motivation for further study. That independent study can sometimes achieve these ends is indicated by the Colorado, Whitworth, and Michigan experiments. But the paucity of positive results suggests that we need more research on methods of selecting and training students for independent study, arranging the independent study experience, and measuring outcomes.

Simulation

As remote terminals of computers begin to sprout throughout the campus, simulation is likely to take the place of television, independent study, and programmed instruction as the glamor method of the 1970s. Simulation refers to any arrangement that duplicates certain features of the environment in order that students may experience a situation which they may later encounter and learn skills useful in handling the real-life

situation being simulated. Examples of simulation methods used in teaching vary from simple role playing to complex business or international relations games (Ericksen, 1966). Simulation does not necessitate the use of a computer, but computers can assist in providing rapid calculations and prompt feedback on the results of decisions. According to theory, the active participation, uncertainty as to outcome, and prompt feedback are motivating and effective for learning.

Presumably, simulation can be used for almost any subject matter. For example, in science courses, the variables and equations of a theory can be programmed onto a computer and students given the task of designing experiments to run on the computer to test their hypotheses about "nature" as represented in the computer. Medical students have used simulation in learning diagnostic skills. Simulation is presently most common in teaching political science and business courses, although there are some games used in education courses and other fields.

Only two college-level studies have evaluated the effectiveness of simulation. Results favored simulation only modestly even though a variety of outcome measures were used (Hershey, Sheppard, Krumboltz, 1965; Robinson, Snyder, Anderson, and Hermann, 1964).

Many instructors have for years offered students some options in the manner in which they might achieve the goals of a course. Recently, however, there has been an upsurge of interest in the possibility that offering options would increase student motivation and enable differing students to learn in the way most effective for them. Pascal (1969) studied Gurin's course in which psychology students had the option of lecture, lecture/discussion, or independent study. The opportunity of choosing a method of learning versus being assigned one did not significantly affect performance on tests of learning, although students assigned their preferred method ended the course with more favorable attitudes toward psychology. Davis, Marzocco, and Denny (1970) similarly found no significant effect on learning when students were given a choice of differing modes of programmed instruction.

Student Characteristics

We have already referred to differences in student reactions to some of the teaching methods discussed. No one method seems best for all students. Let us review some student characteristics that affect reactions to teaching.

Intelligence. The more intelligent student does better than the less intelligent student in most educational situations. But it does make a difference how students of differing intelligence are taught. Remmers (1933) in three experiments comparing varying combinations of lecture and recitation found fairly consistent results favoring a greater proportion of recitation for abler students and a greater proportion of lecture for less able students. Both Ward's (1956) and Macomber and Siegel's (1957a; 1957b; 1960) studies indicated that the ablest students are most favorably influenced by small classes. Calvin, Hoffman, and Harden (1957) found in three experiments that less intelligent students consistently did better in group problem-solving situations conducted in an authoritarian manner than in groups conducted in a permissive manner. The same difference did not occur for bright students. All of these findings probably point to the fact that the small-group discussion method is more appropriate for bright students than for less able students. But intelligence is not enough. Seigel and Siegel (1964) found that low ability students performed better on a test of conceptual acquisition if they had been previously tested with an emphasis on factual rather than conceptual learning. High ability students were affected by the difference in methods in terms of their previous knowledge. That is, high ability students with high previous knowledge benefitted from emphasis on conceptual learning while unsophisticated high ability students (like low ability students) performed better on tests of conceptual acquisition when previous emphasis had been on factual learning.

These results conform with the wisdom of college faculties who have generally urged the institution of smaller classes, greater use of discussion and establishment of a higher conceptual level in honors classes. The findings of Siegel and Siegel, however, inject a cautionary note. The naive, bright student is, perhaps, more like the less able student than is sometimes recognized by college honors committees.

Cognitive style. Some students are predisposed to learn facts, other to apply and synthesize facts. In an experiment on televised instruction at Miami University, the fact-oriented student was particularly helped by personal contact with the instructor. Students with little prior knowledge of a subject matter also benefitted particularly from personal contact with the teachers (Siegel and Siegel, 1964). In a later publication (1966), however, Siegel and Siegel point out that the effect of personal contact with the instructor depends upon what the instructor does. In their research, they found that some instructors used the class period for clarification of the lectures, others for further exploration. The high ability student benefitted from personal contact when the contact involved *exploration*, but the low ability student benefitted from *clarification*. It is clear from these results that getting to know the instructor personally is not the answer to the student's problems. The effect of personal contact depends upon the sort of interaction, student, and the fit among student orientation, instructor goals, and method used.

Comparing students in conventionally taught classes with those in which students were given major responsibility for the course, Patton (1955) found that the degree to which the student accepted responsibility in

the latter class was positively correlated with his gain in ability to apply psychology, rating of the value of the course, and interest in psychology. But what sort of student accepted responsibility in such a course? Patton found that the students who liked his experimental class and assumed responsibility were likely to be without traditional authority figures and high in need for achievement. Goldberg (1969) found that self-study students measuring high on the CPI Responsibility factor did better on an essay test than did similar students in a lecture class. In the Oberlin studies (McCollough and Van Atta, 1958), students who were less rigid and less in need of social support gained more in measured achievement from independent study than did more dependent students. Similarly, Goldberg (1969) found that the female students who measured high in "achievement through independence" on the CPI did better in self-study classes than in lecture classes.

Despite the variety of measures used, studies in this area show some consistency in finding that a certain type of student—characterized as independent, flexible, or high in need for achievement—likes and achieves well, at least on a test of application of concepts, in classroom situations which give students opportunity for self-direction.

Authoritarianism. One of the most intensively studied research variables of the 1950s was "authoritarianism." It is not surprising, therefore, that this variable has been studied in relation to college learning.

Watson (1956) studied the effect of permissive and restrictive teaching and testing methods upon students differing in authoritarianism and "permeability" (extraversion). The methods did not produce different results as measured by achievement tests, but they did affect student satisfaction. Highest satisfaction resulted when a student was tested in an atmosphere appropriate for his needs: i.e., permissive for permeable, restrictive for impermeable. This finding is in line with the finding of Bendig and Hountras (1959) that authoritarian students prefer a high degree of departmental control of instruction and with the results of Hoehn and Saltz (1956) in counseling.

In a study reported by Stern (1962), students high on a variable akin to authoritarianism were found to gain more when taught in a homogenous group. The instructor who taught this section found that he had to resist pressures from the students for lectures. He obtained his good results by using many direct questions, encouraging student responses, and by vigorously defending absurd positions which even authoritarian students would challenge.

Sociability-affiliation. Beach (1960) studied the personality variable of sociability as a predictor of achievement in lecture and small-group teaching methods. In the lecture section, the nonsociable students (as measured by the Guilford Inventory of Factors STDCR) achieved significantly more than the sociable students; in small-group sections the results were reversed. The study reinforces the point made earlier. Personal contact with the instructor is valuable for some students, but not for all.

Anxiety. Since anxiety is generally believed to be increased by uncertainty, we would expect the anxious person to work most effectively in a highly structured situation. This hypothesis is partially supported by the research of D. E. P. Smith and his co-workers (1956), who found that anxious students who were permeable (sensitive to stimuli, impulsive, socially oriented, and low in ego strength) made optimal progress in a remedial reading course when taught by directive methods. Impermeable anxious students, however, were more favorably affected by non-directive methods. H. C. Smith (1955) found that students with high anxiety and low initial achievement gained more on achievement tests and were more highly satisfied in a "teamwork" class than in a conventional lecture taught class.

The Interfering Tendency Questionnaire (which correlates well with the Taylor Manifest Anxiety scale) differentiates ways in which students respond to failure (Waterhouse and Child, 1953). Under neutral conditions, individuals scoring high in interfering tendencies do better than low scorers, but after failure the high scorers do worse. This result was confirmed by Williams (1955), who also found that reaction to different types of failure is affected by achievement motivation. Students who were strongly motivated to achieve showed improvement following failure to reach goals set by themselves; students having a low achievement motivation showed relatively greater improvement following failure to reach goals set by the experimenter.

The relationship between anxiety and performance on classroom examinations administered under varying conditions has been the subject of several experiments. To test whether the anxiety created by tests might be dissipated by permitting students to write comments on tests, half of the students in a University of Michigan experiment were given answer sheets with spaces for comments and half were given standard answer sheets. Measures of students' feelings about the tests failed to show any difference between the two groups; but the students who had the opportunity to write comments made higher scores. These results held up in a series of experiments (McKeachie, Pollio, and Speisman, 1955). They suggested that student anxiety during classroom examinations builds to such a point that it interferes with memory and problem solving. Reducing the stress of the examination by permitting students to write comments results in improved performance. In view of the results of Waterhouse and Child, and Williams, we should expect this effect to be greatest for students high in anxiety.

This interpretation is supported by the work of Calvin, McGuigan, and Sullivan (1957), who found that students who were given a chance to write comments on an achievement test were superior to control students in

their performance on the second half of the test, and that the students who made the greatest gain were the highly anxious students (as measured by the Taylor Manifest Anxiety Scale). Similarly, W. F. Smith and Rockett (1958) found that instructions to write comments significantly interacted with anxiety in that it helped improve the performance of highly anxious students but hurt the performance of students low in anxiety.

An Air Force experiment on teacher-student interviews also revealed complex interactions. Although the interviews were not effective overall in influencing achievement, Hoehn and Saltz (1956) found that anxious students tended to be helped by interviews, while rigid students were more likely to fail if interviewed. The results were further affected by the type of interview; interviews in which students were encouraged to gripe produced the interaction noted above, while interviews oriented toward the student's goals and sources of satisfaction did not. If this result can be generalized to the testing situation, we might expect the "comments" technique to be unsuccessful for rigid students.

The experimental results concerning the interaction of anxiety and teaching variables are tantalizing enough to stimulate further work, but they are not consistent enough to lead to any stable generalizations. It does look as if anxious students react badly to failure and are helped by chances to express themselves. But the fact that differences in sex and personality variables, such as permeability, interacted with anxiety in the experiments above suggests that multivariate designs are necessary to explore this area adequately.

Sex. Our coeducational institutions may have a vested interest in the assumption that the best education for men is also the best for women. In any case, until recently very little research dealt with the differences in learning styles of men and women.

Carrier (1957) investigated the manner in which individual differences in four personality variables affected performance in more and less stressful situations. He found that one of the most important variables determining reaction in his experiment was sex. Women were much more detrimentally affected than men by his stress situation.

In a later experiment (McKeachie, 1958), half of the students in a large class received a tranquilizing drug, meprobamate, while the other half received a placebo just before an examination. It was hypothesized that if students tend to be too anxious, such a drug should improve test scores. The results did not confirm this. Students who actually had Miltown reported experiencing less anxiety during the examination than did the placebo group, but they did not make better scores. The really interesting result of the experiment was the sex-drug interaction. Women benefitted from the drug more than men. Thus sex once again turned out to be an important variable. The results make sense if we assume a curvilinear relationship between anxiety and performance, with women too anxious and men less than optimally anxious. Reduced anxiety should therefore result in improved performance for women, but poorer performance for men.

With the current interest in uniting men's and women's colleges, one would expect some interest in research on the differences in college learning between men and women. The results cited above suggest that the most effective methods in teaching men are not necessarily those most effective with women. Does this mean that there will be a loss in effectiveness when men and women's colleges combine? Perhaps not, for Hoffman and Maier's (1965) research suggests that women are more effective in problem solving in groups containing both men and women than in homogeneous groups.

Conclusions

Where do we stand today with respect to research on college teaching? Certainly progress has been made since the author's 1963 review (McKeachie, 1963), but the same methodological problems persist. The criterion problem still looms large. Researchers persist in using course examinations as outcome measures even though such examinations have proved to be insensitive (Dubin and Taveggia, 1968). Moreover, final examinations are very likely to be contaminated if they are constructed by the teacher or author of the teaching program. We do not prove much if we find that a student who has been previously exposed to a particular item of content—or even worse to a particular question on the content—is better able to answer a question on that content than a student who was not exposed to it. Ideally, criterion measures should be constructed with reference to course goals and course content in such a way that they sample equally well the possible learning of all groups involved in an experiment.

We need to go well beyond the simplest measures of knowledge. If this review does nothing else, I hope that it demonstrates the value of measures of retention, critical thinking, attitudes, and motivation—all difficult both to construct and to administer—but essential if we are to progress. As we develop such measures we need to think more analytically about what differences we should expect. Different methods imply differing goals; yet we have often failed to use the criterion measures most appropriate for a particular method or for a particular course goal.

Research on college teaching may result in some principles of general validity. But I suspect that much of what we find is valid only for a given culture at a given time. We need to begin to establish the sort of continuity in research that will enable us to spot trends in student learning and relate changes in student responses to differing teaching methods to changes in the elementary and high schools, changes in child rearing practices, or changes in other aspects of the culture. What worked for

teachers a generation ago may not work today or tomorrow.

My emphasis on the effects of interaction is well known, and readers should be warned that my optimism about adapting teaching methods to differing types of students is not strongly supported by research evidence. Both Cronbach and Snow (1969) and Goldberg (1969) come out with rather pessimistic conclusions about research on interaction effects. My own rationalization is that teaching and learning is an enormously complex business in which so many variables are involved that interaction effects, like methods effects, pop up only a little way above the apparent noise generated by other variables. We need to do more and better research, but I doubt that any new models or new variables will suddenly sort out all the variance into large, meaningful categories.

Where do we stand today with respect to *teaching methods*? It is clear that there is no one best method for all goals, students, or teachers. Rather, what is the best method is a function of each of these variables. We do know more in the area of theory and research on classroom teaching than we are usually given credit for. We have seen fairly convincing evidence that differing teaching methods do make a difference in learning if one analyzes the different goals of education. Other things being equal, small classes are probably more effective than large, discussions more than lectures, and student-centered discussions more than instructor-centered discussions, for the goals of retention, application, problem solving, attitude change, and motivation for further learning.

Readers who have seen newspaper reports of the studies reviewed by Dubin and Taveggia (1968) may be shocked by the seeming difference of our conclusions. But the Dubin and Taveggia review deals only with the effects of teaching on course examinations. The results presented in this paper substantially support their conclusion that so far as performance on course examinations is concerned, there is no strong basis for preferring one teaching method over another. When one asks, however, whether knowledge (1) is remembered after the final examination, (2) can be applied to new problems, or (3) is related to attitudes and motives, we find that class size and teaching method do make a difference.

We also have seen some evidence that different teaching methods work well for differing types of students. This too implies that a variety of methods should be used in a college and in a course. One would hope that each student would be "turned on" by some aspect of the course even though other aspects might be relatively unattractive to him. Because teaching methods are differentially effective for differing students and differing kinds of learning, the teacher must make value decisions about what he wants to aim for as well as strategic decisions about his means to these goals.

When we say that the use of discussion is more effective than lecture in building problem-solving skills, there is always the implicit proviso, "other things being equal" or (even better) "as usually practiced." One does not always have a choice whether a class will be small or large or even whether it can be taught by discussion or lecture. Still, one is not thereby foredoomed to focus on lower-level objectives. With imagination and planning, any teaching situation can produce better than typical achievement of any educational goal. For example, I have suggested that discussion helps develop problem-solving skills because students have an opportunity to practice problem solving in class. If these skills are important goals, an instructor in a lecture class could undoubtedly give students practice in problem solving (with feedback) either during the lecture itself or as written assignments. Research is needed on the effects of employing such differences in methodology within the major methods traditionally studied.

College and university teachers are increasingly attacked for not increasing their productivity to the same degree as factory workers. But the analogy is not apt. Certainly communication of knowledge can be carried out more effectively. A teacher can lecture to 100 as well as to ten; he can televise his lecture to thousands; or he can write a book and teach hundreds of thousands. But insofar as the goals of education involve the development of thinking, increased motivation for learning and other goals requiring the student to talk or practice with feedback from a teacher, we cannot greatly increase productivity. *The technological bottleneck in education is that we have no device that allows a teacher to listen or respond to more than one student at a time.*

One implication of these findings is that we should expect to find a variety of teaching methods used within a college and that teachers should develop a repertoire of skills. Within a course, students can be offered various options to maximize their motivation and learning. By specifying goals clearly and helping students think through their own learning skills and needs, the teacher should be able to improve student learning. With increasing knowledge, we should be better able to match means and ends, varying our procedures from day to day and student to student as our different goals move in and out of the spotlight.

All of this adds up to the notion that effective college teaching is a very complex business. But the very complexity of the teaching situation is the source of its challenge to creative minds. Research can help to lay bare the deepest properties of our teaching while revealing to us more wonderful intricacies. As we gain in our understanding, our teaching will be illumined with new insight, delight, and mastery.

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